

Integration of iPad-Based M-Learning into a Creative Engineering Module in a Secondary School in England

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ABSTRACT

Mobile learning (M-learning) has become a popular topic in educational research, in previous research there have been many studies on attitude to M-learning directed towards staff, parents and students; however, limited research has focused on the comparison between teachers and students in the context of creative engineering and their respective opinions on issues of M-learning (iPad-based), comparing with other stakeholders' opinions. The study investigates the integration of iPad-based M-learning into a creative engineering module in a secondary school in England, applying a problem-based learning pedagogy. By using a case study approach involving semi-structure interviews, group interviews, and observation, the research participants, this research found that all of whom were involved in the creative engineering module, have a relatively objective and rational opinion of the affordance of the iPad, and the teachers were generally positive about the benefits of iPad-based M-learning in terms of discussing how it has changed learning as a whole. The results also challenge previous claims that the outcomes of M-learning are difficult to assess, thereby advocating a case-to-case assessment of the outcomes of M-learning. Some limitations of iPad-based M-learning were first discovered. The school's iPad policy integrates building of an online platform, evaluating teachers' belief in iPad-based M-learning and the expectations of students, irregular teacher-student communication, teachers' and students' self-training to facilitate iPad-based M-learning. However, the formal training in iPad use provided by the school was not well thought of by the research participants.

Keywords: ipad-based mobile learning, creative engineering, secondary school pedagogy

Abbreviations : M-learning (mobile learning); PBL (problem-based learning); CE (creative engineering); CE students (creative engineering students); T1 (teacher 1); T2 (teacher 2); T3 (teacher 3)

INTRODUCTION

This study compares how stakeholders think of iPad-based mobile learning (M-learning) is incorporated into a creative engineering (CE) module in a secondary school in England. M-learning, due to the advent of different kinds of mobile devices and their attractive and futuristic affordances, has attained popularity in education (Brand et al., 2011). In particular, the introduction of the iPad, by adding new functionalities to mobile devices, has reinvigorated scholars' and educators' interest in M-learning (Kinash, 2011). Indeed, many schools in different locations worldwide have started to pilot iPad use for teaching and learning, prompting many studies that are focused on the potential benefits of iPad-based M-learning.

In general it has been found that people exhibit a positive attitude towards iPad-based M-learning (Melhuish and Falloon, 2010). However, behind this trend favouring the iPad, there are questions over the compatibility of iPad-based M-learning, the genuine nature of its efficacy, and its so-called power to transform learning (Cochrane, Narayan and Oldfield, 2013). These doubts, as they relate to iPad-based M-learning and the pursuit of a futuristic ethos, adoption of new functions, and the potential benefits they represent are carefully considered in this dissertation. It also investigates the way in which iPad technology can bolster interest in those subjects that have previously been problematic to teach; in this case, specifically creative engineering.

LITERATURE REVIEW

Mobile learning

Following the advent of digital mobile devices, such as the iPod, iPhone and PDAs, and particularly with the increasing popularity of tablet computers such as the iPad, mobile technology is having profound influences on

peoples' lives (Attewell, 2005). The iPad achieved record sales of “twenty five million units...within the first fourteen months (of its inception)” (Jobs, 2011 cited in Oldfield and Herrington, 2012, p.1). This figure emphasises its impact on the use of mobile devices and their role in future living (Garcia, 2011). In the field of education, mobile technology is referred to using the buzzword ‘mobile learning’, which is normally abbreviated to M-learning (Brand et al., 2011). Increasingly academics and other interested parties are exploring the potential benefits of M-learning as a favoured and modernising approach to education (Kinash, 2011). According to Jardine, Clifford and Friesen (2008), because of its unique qualities, M-learning is emerging as best practice for teaching and learning; although concerns over its uses are still expressed in some circles.

Definitions of M-learning vary in accordance with different perspectives. Generally speaking, there are four strands that define M-learning: focusing on technology, focusing on changes in learning and teaching brought about by improved mobility, blended types focusing on both technology and changes in teaching and learning, and a purely behavioural description. In reference to the former, Beetham and Sharpe (2007) cited in Brand et al. (2011, p.169) defined M-learning as “technology driven, miniature and portable and as facilitating connected classroom learning”. Similarly, Wang, Wu and Wang (2009, p.99) defined M-learning as teaching when “content is received through wireless internet and palm-sized computers, and thus M-learning usage can be considered to be a natural extension of computer use”. Based on the aspects of changing in learning and teaching, Motiwalla (2007) defined M-learning as a strategy that empowers learners by delivering learning anywhere at any time. Sharples et al. (2007, p.225) defined M-learning as “the process of coming to know through conversation across multiple contexts amongst people and personal interactive technologies”. Similarly, Melhuish and Falloon (2010, p.3) claimed the primary characteristic of M-learning to be “just-in-time, situated learning, mediated through digital technology in response to the needs of the users”, which also symbolises a change in learning and teaching. With regard to the blended type, Kinash (2011, p.56) described M-learning as “a portable process of teaching and study using internet-connected devices such as laptops, tablets and smart phones”. The fourth categorisation, the purely behavioural element, is reflected here: “M-learning means that students are tweeting questions, searching expert opinion, voting and ranking, viewing demonstrations, visually mind mapping and constructing and sharing expressions of their ideas in formats such as animations and movies” (Kinash, 2011, p.57). However, it is advisable for researchers to treat all definitions of M-learning cautiously, because it is an evolving and multi-faceted area.

Affordance and features of iPad-based M-learning

The iPad shares many similarities with smart phones, laptops, and e-readers (Melhuish and Falloon, 2010). However, it is an outstanding example of these. Unlike the normal smart phone, which people hold in their hands, or the laptop, which can be heavy and has an upright screen, the iPad is a light weight gadget as flat as a piece of paper and as thin as the diameter of a pencil. Thus, users can hold it, put it on a table, or stand it using a cover. It is described by Wray (2011, p.2) as “more of an extension of one’s body rather than a separate machine”. Therefore, users often keep it close at all times, similar to their mobile phones. He also pointed out that due to the streamlined design of the iPad, schools find it easier to store than a desktop computer, and can therefore fully utilise the device (ibid).

The iPad has a large and flexible touch screen, which can be used as an e-reader, but has more expansive colour and functionality. Therefore, at some institutes, students are starting to use the iPad instead of paper books and journals (Cochrane, Narayan and Oldfield, 2013). Most importantly, the wide screen design makes it possible for a group of 3-4 people to watch at the same time, fulfilling classroom needs (Li, 2012). iPad’s touch screen facilitates straight forward user control, and Wray (2011, p.3) has claimed that “controlling iPad with direct touch from the user makes such use a different, involving and pleasing activity”. The iPad also has its own unique operating system, the desktop Operating system (OS) which, according to Wray (2011) extends battery life. Therefore, it can to a large extent satisfy the demands of schools and users by outperforming the common laptop.

Most important of all, the iPad combines many gadgets with different functions. An iPad can function as an e-reader, a camera, a computer, a voice recorder, a drawing pad, an Mp3 player, and a port to the Wifi or 3G network. Therefore, according to Wray (2011, p.5), upon adoption of the iPad “educational organisations no longer need ICT suites” and due to its user-friendly design, “it could also be the start of a large reduction in the role of the technician in providing the technical support many schools need with their technology”. All these affordances of the iPad contribute to its popularity, as do the accessibility to applications (apps) using the device.

iPad Apps

Customised apps are one of the core affordances of the iPad. According to Brand et al. (2011), the number of apps for use with the iPad and other similar products is increasing. Not only is Apple specifically writing apps

programs for iPad and its other mobile devices (Wray, 2011), but also textbook publishers and learning management system firms (Brand et al., 2011) are producing apps. This is a reflection of Melhuish and Falloon's (2010, cited in Naace, 2011) concept of effective apps: "they must be pedagogically sound in their design". However, in terms of other descriptions of good apps, Melhuish and Falloon (2010 cited in Naace, 2011) note that they "foster interactions that are grounded ... in M-learning theory, rather than focusing solely on content, engagement or edutainment" (ibid); but there is not much research or evaluation. Generally speaking, at present there is significant scope for further development of iPad apps, particularly for educational purposes. Wray (2011) stressed that it is necessary for educationalists working together with apps developers to produce better apps.

Training and support of iPad-based M-learning

The affordances of iPad based M-learning have been discussed. As has been stated above, the objective assessment of the affordance of mobile devices is essential when availing learners of potential opportunities (Melhuish and Falloon, 2010). Furthermore, how much and to what extent the affordances of an M-learning device are understood by practitioners determines the extent to which they are used in learning and teaching (Churchill, Fox and King, 2012). However, there are thousands of apps as well as different functions associated with mobile devices; thus, teachers can become confused about how best to select and apply these specific affordances in their classes (Wakefield and Smith, 2012). As the iPad and other similar devices are multi-functional and desirable gadgets, they contain features that can distract students (Morris, Ramsay and Chauhan, 2012). It should not be assumed that because the students are digitally aware, they are able to make use of the educational affordances of the device. Thus, relevant training to support iPad-based M-learning is essential.

Furthermore, according to Wakefield and Smith (2012), the solution to teachers being unprepared to use the device and its affordances is to instigate teacher training programs. Similarly, Morris, Ramsay and Chauhan (2012) suggest that encouragement to use mobile devices should also be given by training students in schools. However, neither group of authors mentions the importance of communication between teachers and students, and between teachers when dealing with affordances. Nor do the authors mention the importance of teachers and students' engaging in M-learning self-development. Churchill (2005) claimed that teachers' use of technology is largely influenced by their own private theories. Different teachers using the same device and apps may engage in different practices. Similarly, students always surprise their teachers by making "extensive use of some technologies to support their studies and virtual learning environment, often beyond their university's expectation" (Morris, Ramsay and Chauhan, 2012, p.98). Therefore, we might expect that through communication and sharing ideas teachers and students would be successful at acquiring M-learning knowledge and developing new methods for use.

When using iPad based M-learning, unique challenges related to the iPad emerge. One of these is the support offered in schools, for example, whether Wifi is widely accessible in school (Garcia, 2011). Another problem relates to ownership of the device. According to Traxler (2010), the iPad is intended to be a personal device, the effect of which would only be realised as optimum when each person has one (Naace, 2011). Until now, many researchers have conducted studies in schools which have a limited number of iPads for students to borrow, or who only use them occasionally in class (Kinash, 2011).

Research rationales and research questions

In previous research there have been many studies on attitude to M-learning directed towards staff, parents and students; however, limited research has focused on the comparison between teachers and students in the context of creative engineering and their respective opinions on issues of M-learning (iPad-based), and other stakeholders. Such a comparison, therefore, might raise new issues that have not been previously discussed. It has been discussed that the incorporation of M-learning into pedagogy is sometimes confined by standardised exams and the traditional curriculum; however, in the case study at the centre of this research, the CE class observed consists of students who are not studying to pass exams, and for whom the curriculum is brand new. Furthermore, the pedagogy of CE is problem-based learning, and there is minimal research combining a problem-based learning pedagogy and iPad-based M-learning. Thus, enquiring about how M-learning (iPad-based) is incorporated into CE pedagogy should to some extent contribute to both M-learning theory and engineering education.

This study will investigate how teachers and students were trained and self-trained before using iPads in class. It will also investigate whether there was any teacher-teacher or teacher-student communication focusing on the affordance of the iPad. Meanwhile, it is necessary to know how school A supports iPad-based M-learning in terms of policies, hardware and relative facilities.

In order to solve the rationales produced in the literature, the following research questions have been created: What do stakeholders think are the advantages of iPad-based M-learning? To what extent do the stakeholders think iPad-based M-learning or grades? To what extent do stakeholders think the improved outcomes for the students could be assessed? Can the iPad transform learning and is it just another learning resource? How were creative engineering teachers and students trained and supported in the use of iPad-based M-learning?

RESEARCH METHODOLOGY

In order to answer the research questions, the researcher designed a case study. Semi-structured interviews and group interviews were respectively set for CE teachers and student. Semi-structured interviews share both the flexibility of unstructured interview and the organisation and consistency of a structured one (Newby, 2010). Flexibility is demonstrated when the researcher feels the need to explore a certain point by asking follow up questions (Newby, 2010; Robson, 2011). In the current study, if interviewees are asked about how they use iPads in CE, they are likely to mention certain apps or functions. Therefore, the flexibility of a semi-structured interview may help to attain a clearer picture of CE students' and teachers' practices, as it allows for follow-up questions. Group interviews are time-saving by nature, and when conducted carefully are unlikely to damage data gathering, due to their respect for the integrity of each participant's opinions (Cohen et al., 2011). In the current study, the group interview choice was made predominantly on the grounds of the busy schedules of both the teachers and the individual students. Furthermore, group interviews are structured according to defined topics (Gillham, 2005). Putting groups of interviewees together to discuss research topics in a certain structured order is helpful when organising data. A group interview will enable and encourage interviewees to cross-check each other's comments while at the same time complementing and inspiring one another (Newby, 2010). It is hoped that this process will result in a more in-depth answer and therefore a more abundant data store (Arksey and Knight, 1999).

Non-participatory observation, to be more specific, the "inactive and known" (researcher merely standing aside and not join the activities of participants) (Newby, 2010, p.367) is used herein. According to Frank (1999, p.82), in a familiar environment, the researcher is prone to miss "hidden" or "invisible" information, and the involvement of a researcher may influence his or her judgment of the context. Therefore, engaging in active and known non-participatory observation may enable the researcher to see the researched issue from a different perspective to insiders; to focus on observing participants' behaviours; to distinguish whether their behaviours are similar to what they have described, or whether a new phenomenon emerges (Newby, 2010).

Nominated sampling was used when choosing interview participants at school A. According to Morse (2004, p.885), "nominated sampling... is particular useful when groups are hard to identify or may not volunteer or respond to a notice advertising for participants". The main reason for using nominated sampling was that it was difficult to contact the CE teachers and students as a visitor. Another reason was that due to the teachers and students all having tight schedules, nominating particular people to participate in interviews at particular times was beneficial for school management as well as for the participants. Recommended by the principle of this school, three teachers teaching creative engineering were summoned; a cohort of ten CE students were arranged by their teachers to participate a group interview, and the students were all had been using iPad to study creative engineering for more than a academic year; furthermore, another group of four who was about to participate the CE in the next academic semester was also chosen for the purpose of comparison. The research data was collected using a voice recorder for interviews, and for observations with field notes. Respondent triangulation was also used in this research to assure the research validity by 'comparing many sources of evidence in order to determine the accuracy of information' (Bush, 2012 p.84), which means making enquiries about different participants and consistently asking the same questions (McFee, 1992). In this research, the teachers and students were asked similar questions in a structured order. Thematic coding was achieved using Nvivo 9 to analyse the qualitative data. The data collected for this research was gathered and organised according to the research question it pertained to.

FINDINGS

What do they think are the advantages of iPad-based M-learning?

T1, T2, T3 and the CE students gave some similar opinions when defining the advantages of the iPad, for example the advantage of gaining "independence"; however, in their perspectives on other issues were diverse. In addition to the direct participants in the CE module, a group of pre-CE students who had not yet been enrolled in CE were also interviewed; their opinions offered a contrast to those of other CE members. The data is organised according to participant type in themes.

T1 considered two different perspectives when answering the question: the benefits to students' abilities and those to practical study. T1 concluded, when asked about the advantages the iPad brought to enhance CE

students' ability, that "it's building their resilience, their problem-solving [skills], their independence, [and] their creativity". He particularly emphasised students' increased independence to be the product of "the combination of the problem based learning and the mobile technologies", which "is allowing them to work and think more independently". Moreover, he also gave some examples of the advantages of iPad in terms of practicality, for instance, "flexibility and the whole range of different applications it's got". He also said "they can almost work electronically and faster but also it's giving them immediately access to the internet and information research" and "they can go straight on maybe to YouTube and find a tutorial". Therefore, from the above quotation, it can be concluded that T1 believes the advantages to be flexibility, speed, supportive, accessible online content and the support of apps.

In addition to independence, T2 pointed to the modernity of the iPad as an advantage, saying that "[As] we're doing a creative engineering course you'd like to think that what we're doing is quite futuristic... the ethos of the course is creative engineering, we're meant to be creative and we are when we use the apps... we're talking about current developments in technology and you can't get any more current than this [the iPad]"; "it fits nicely with what the remit of the course is."

Furthermore, he also mentioned convenience, stating this is due to "the ease of use basically . . . it's easier to give feedback on work because the work comes in and is delivered straight to your iPad so there's no chasing work around as it were." In contrast, T2 stressed the advantages of the iPad in bringing an up-to-date and futuristic quality to the CE module, also mentioning the practical value of the iPad in terms of convenience. Interestingly, T3's ideas also differed from those of T2. Aside from citing "independence", he stressed mobile, collaborative and supportive elements as the advantages of the iPad. He said:

"We feel that it's a little bit more mobile. So that rather than going to a classroom, booking a classroom and having all of the students log on to find various things that they would need IT for they can use that as they're moving around".

He then added, "I'd say pace to work collaborative learning where they can be more collaborative with the sending of things, with the working of things, working together, are the main reasons why we use", and claimed that "they all work on different projects and I can't be an expert in every single part of engineering, I'm not an engineer". From T3's quotations, it seems that he was considering the advantages at a more practical level.

In terms of current CE students, it is interesting that they also expressed independence as an advantage of the iPad, in that they valued "the management side of it is you can choose what you do, like you can choose the certain apps that you want to use for the research and stuff". "Speed" is another word extracted from their responses: "I think one of the main aspects is probably the speed" and "it's quicker to do it on an iPad than a PC". Furthermore, "more apps, more choices" is also an advantage mentioned by the CE students: "You've got a lot more technology that you can actually use like the apps allows you to do stuff that you wouldn't be able to do on the computer"; "the apps are a lot better than the actual computer systems because it allows you to get a lot more on iPad" and "you can choose different apps for education."

From the transcripts, it can be seen that the CE students enjoy the inherent affordances of the iPad, such as speed and supporting apps, which is understandable when recalling that they were designing a racing car using an app called Wind tunnel, thereby engaging in engineering research. The strong and diverse apps indeed offer the students the techniques they require, along with fast access to the internet and any apps or functions associated with the gadget.

There was also a group interview with a number of students not yet enrolled in the CE module. Their answers to the question differed from those of those learners currently on the CE course. Although there were some similarities, for example, the advantages of speed, "you can look up stuff easier than going on a computer"; and convenience, "you can like directly quote things as well" and "if you've done some work at home then you can just put it on your tablet or your iPad and then you can bring it in and you can access it at school as well without having to do drop box or anything like that or Google plus". Mobility was also mentioned: "it's more portable" and "it's lighter as well than a big textbook."

Yet what distinguished these students from those doing CE were the advantages they mentioned: multi-functional, learning being easier and more fun. Firstly, they mentioned multi-functional as an advantage: "it's also like if you're in the other classrooms then you don't have to book a computer suite." Their viewpoints seemed to confirm that the iPad could replace the entire computer suite in future. However, in real CE studies, on many occasions, the functions of the iPad were found not to match a computer. For example, in the follow-up

interview with T1, he indicated that “they [students] have to do the programming in the Mac Book, the iPad can’t affect the programming”; the CE students also said “they’re [iPads] not as precise as computers because you have the mouse and like you can do better.” Therefore, from the perspective of those involved with CE, the iPad is not perfect and should sometimes be used only in cooperation with other materials. Additionally, the pre-CE students seemed certain that the iPad would make learning fun: “students are more enthusiastic about it and when you can bring something they’re interested about and combine it with learning then you get like better results” and “people are always bored if teachers hand out textbooks and you immediately textbook, urgh, I’m not doing this lesson. But is you can just use you iPad and your tablet then it’s their own stuff”. Whereas, in comparison, to the CE students, the second group of students’ answers seems light-hearted and not objective or rational. This difference could be due to the CE students being involved in the engineering work through design, research or experiments, and it is very likely they have more opportunities in evaluating some functions of the iPad and making comparisons with other techniques after experiencing both. Generally speaking, the interpretation of the advantages of the iPad relates to the roles of the people involved and the ways in which they use it.

To what extent do they think iPad-based M-learning could improve students’ learning or their grades?

From the transcripts, all the CE staff seemed to have a positive attitude towards the benefits the iPad can bring to CE students’ learning. Despite this, none of them mentioned whether the students’ grades could be increased as a result. This is due to the fact that the CE module does not offer examinations; T3 said, “we are not giving a grade; it has the outcome and a certification that goes with that outcome.” However, as summarised previously, T1, T2, and T3’s focuses are different. T1 is positive in terms of the influence of the iPad from a theoretical level, as well as in a long run:

“It can transform the way that you learn and it can allow children to learn in ways or achieve things that they couldn’t have been able to do before”; “it’s transforming both the way in which they learn, the freedom or the greater control they can have over the learning but I also think it can deepen the learning through.”

When it comes to T2, he not only admitted that students’ learning would be improved: “I can basically see the benefits, I can see the benefits”, but also their grades:

“Do you think the iPad can improve students’ marks and scores in exams? R: Yes, definitely”; “In terms of creative engineering do you think it improves their performance? R: yes definitely.”

He gave an overall explanation from both an administrative angle and from the point of learning efficiency, which is consistent with his role in CE:

“They’re using current technology, they’re able to access information faster, they’re able to get feedback off us quicker, we’re able to administer things better which frees up more time for us planning the quality of the resources.”

He also said “in terms of improving learning I’d say it’s easier to give feedback on work because the work is coming in and it’s delivered straight to your iPad so there’s no chasing work around as it were” and that “in terms of improving learning as well like I say it allows them any access to any research that they want to do using the internet of course”; “in the way that if they’re able to access learning faster, if they’re able to receive feedback off me quicker, then that surely is going to improve the grades. If they’ve got access to applications which allow them to work in different ways then they might be able to find a way which is suited to them rather than one way for all, pen and paper which is what it is.” T3 was asked the same question, and confirmed that students were improving in terms of outcome because of the constant feedback: “they come to us and say what about this, I’ve done this, how can I go move forward; so it’s all about me just facilitating once we’ve set up all the information that they need.” Differing from the T1 and T2, he looked at this question just in terms of the scope of teaching and learning.

However, with regard to the CE students, their opinions towards whether the iPad could improve learning and grades differed from each other. Many of them admitted that the iPad could improve their learning, for example, “For like revision and stuff, my GCSE Science which is on YouTube and it’s just quicker to load it up then finding a page in a textbook, so it’s a lot easier. So the score might improve from quicker”; “In maybe coursework kind of sides yes and also because there’s my GCSE science it’s on YouTube which it’s easier to get on an iPad then on anything else; I’ve been using that for science revision today so.”

Furthermore, some students held the belief that use of the iPad would improve their grades: “Do you think your score has improved than before? R: Possibly yeah.” However, when asked about their grades being improved, they must obviously have been referring to other subjects that offer exams.

However, many student participants rejected the possibility that their grades might be affected, for example: “I think that the iPads don’t really do that much really to increase your grade, but you can probably do that same thing on a PC as well so sort of pros and cons to improving your grades.” Similarly, another claimed “I think some aspects of using iPad will help improve but mainly it’s just down to what you know and there’s stuff that you can do on a computer that you can do on an iPad that I’ve been using to help improve my scores. I don’t think they make a huge difference.” Their opinions seem to consider the iPad and the traditional laptop or computer as similar. There are also different explanations of why they do not think the iPad will necessarily improve their marks, for example: “it’s because it’s quite a big grade boundary that’s all so I’ve been usually getting it as an A* so it’s quite difficult to improve on” and “not really, science has always been my strongest subject but it’s gone up by a bit, my marks have improved but the grade hasn’t”. It could be understood that many of the CE students are very good at certain subjects, such as science or chemistry, and that their strengths or interests sometimes contribute external factors, which influence their academic outcomes. Therefore, it is difficult to assess whether the iPad has improved their grades.

To what extent do they think the improved outcomes for the students could be assessed?

In terms of assessing the outcomes for students after using the iPad, T2 seemed slightly negative. According to him, on the subject of the assumed method of assessing the outcome: “you’d have to do it with a sample of students and say look, generally this cohort of students is about the same sort of demographic, the same ability as that set of students, they’re the ones with the iPads, they’re the ones without the iPads. Take away any factors between them, that’s the way you’d have to do it I could guess”, but he also said “I’ve not really given that much thought to be honest.”

In terms of T1 and T3, they both indicated that the nature of the CE module means that it cannot be assessed in a summative way; therefore, it was not possible to offer any grades. T1 said, “that’s a difficult one for us at the moment in terms of having hard numbers because this course is designed to give them experiences which aren’t examined, there’s not an examination”, and T3 stated, “we are now giving a grade; it has the outcome and a certification that goes with that outcome, if they don’t have it then they haven’t passed it” and added that “if they didn’t produce their essay they didn’t go to Warwick, they didn’t get a certificate for the portfolio so the assessment’s different I suppose.”

Although the CE module does not use summative assessment, T3 claimed that formative assessment had been used, which is also how she thought CE students’ learning outcomes could be guaranteed:

“So our feedback is formative and written to how to improve rather than it is to give them a grade’ and ‘they [students] come to us and say what about this, I’ve done this, how can I go move forward; so it’s all about me just facilitating once we’ve set up all the information that they need.”

In relation to this point, because the iPad facilitates the delivery of feedback, in this instance it is assisting in formative assessment.

Furthermore, one student from the pre-CE group gave an idea of how he assessed his progress; he said, “like in English I’m not very good at spelling so now I’m typing it up it’s underlined what’s wrong so I can change that and then I’ve got a higher mark because I’ve not got loads of spelling mistakes all over the page.” In this way, the improved performance as a result of the iPad could be assessed.

Can the iPad transform learning and is it just another learning resource?

In answer to this question, T2 responded: “So do you think it can completely change learning? R: Given enough time yeah. Given enough time probably.” The reason he stressed the need for more time was his belief that many obstacles remain unsolved; for example, that not all teachers are comfortable with using iPads: “if the teacher is comfortable and willing to go along with the technology and use the technology, it completely transforms it.”

T1’s reaction was very positive: “it is transforming learning, it’s transforming both the way in which they learn, the freedom or the greater control they can have over the learning but I also think it can deepen the learning” and “it can transform the way that you learn and it can allow children to learn in ways or achieve things that they couldn’t have been able to do before.” He also gave an example to support his argument:

“In art, students with the iPad could actually, erm, create their own gallery, they could put that gallery online and they could receive feedback on that. They can look at the different countries they got feedback from, they could consider cultural aspects of the feedback that they’re getting, cultural responses to their art, yeah, from around the world. Now that wasn’t possible before the internet, now that’s not necessarily iPad but before the internet they couldn’t do that but the iPad gives them tools to do that easily, yeah. Now that’s learning that couldn’t have been done without the technologies we have now.”

This example is consistent with T3’s response; he said,

“I think there are times when I am frustrated that there are things that I wish things could be done and they can’t

be done because of how systems can be set up in school and Wi-Fi experiences, etc. Also to do with the potential of things I think, so for example if they were designing the apps are getting better that they have access to but originally there wasn't really much for designing. It's obviously taking that design and then what are you then going to do with that design, how are you going to get it off the iPad and what formats does it work in as opposed to the standard more expensive equipment that you can get."

T3 gave this example in support of his opinion regarding a particular question: "I: I read in some articles that some people have the opinion that the iPad and other tablets are just adding a learning resource, what do you think of this opinion? R: I think in some respects that is correct."

In terms of the opinion that the iPad is a resource, T1 offered a different viewpoint:

"It is a resource but it's also a tool to use. It's not just something you go to and look at, it becomes part of. It's like a car; would you call a car a resource? A car is part of you isn't it, it becomes part of you and your life and it allows you to do things in your life or gives you a lifestyle that you wouldn't have had. A car takes you to places every day that you wouldn't have gone. Well the iPad's like that for them, it can take them to place they couldn't."

As he explained, the iPad is a tool like a car, which actually merges into our lives. In this sense, no matter whether it is a tool or resource, it has changed our learning and "allows you to do things in your life or gives you a lifestyle that you wouldn't have had". Therefore, it is of little relevance to argue about whether the iPad has transformed learning or whether it is just another learning resource.

What do they think of the disadvantages of iPad-based M-learning?

According to the coding, the disadvantages can be generally categorised into seven areas: the default operation system, problems with the apps, the supporting facility, the ownership of the iPad, doubts in teachers' critical awareness of the iPad's affordance, the compatibility between the iPad and other brand products and that it cannot beat face-to-face teaching.

The first point concerns what most research participants have been worrying about, in that T3 argued that the iPad could not provide instant printing: "if I want something very quickly on paper there's no air print facility because of how systems are set up". Additionally, he also complained about the keyboard issue, saying, "it's a new way of typing and the predictive text changes all the time", which is echoed by a CE student who claimed that "you can buy external Bluetooth keyboards but you're spending more money and if you want to do work it's easier to have another keyboard instead of using the onscreen one". The touch screen in many cases seems advantageous, but another CE student claimed that "they're not as precise as computers because you have the mouse and like you can do better"; a further reason provided was that "on a PC you've got a mouse to point but when you're using your fingers you can't really get the, if you're building a model you can't get the right angle and stuff like you can with a mouse so it's quite hard to use it".

The students also remarked that the processes available on the iPad were not as good as those in a computer; for example, "so you needed a PC then to actually get on Solid works and actually carry on designing, so I think that's a main issue with the apps that are available on a PC that you can't sort of just get on an iPad." Lastly, the students also argued that the storage of the iPad was not ideal: "I think the amount of storage space they've got can sometimes limit what you can do on them." Generally speaking, all these limitations relate to the default hardware used, which to some extent means it cannot satisfy the requirements of CE. This is due to, for instance, the precision of the mouse and processing capability of CPU, and even the storage available for saving important design files or models that is critical for CE design and research.

In terms of the problems with certain apps, T3 claimed that it is too tiring to learn to use multiple new apps: "there are just so many applications everyday it's hard to keep up". He also stated that apps are sometimes incompatible with the intended learning aims: "constantly finding a better app for a better purpose because it shouldn't really be about the app, it should be about the learning and the app should fit it but you need to know what the apps are to fit in." As he described, he has to pilot the apps for students in order to be able to recommend them as useful tools for CE. However, his complaint regarding the inconsistencies between apps and lessons, has been echoed by many people; in general complainants advocate a refined M-learning pedagogy with embedded apps specifically designed for certain procedures. Alternatively, T1 pointed out that some of the apps, such as "iMovie", were not as well thought out on the iPad as the iMac: "some of the applications that are on the iPad there are more sophisticated versions on the mac." However, this may be due to the default hardware on the iPad; thus, the problem can only be resolved by producing a new iPad with a more powerful CPU. In cases where students have the opportunity to switch between different technologies, these limitations do not affect learning.

Furthermore, the facilities supporting widespread use of the iPad are also sometimes problems. One student complained: “when you’re out and about you don’t always have internet connection so it’s difficult to research stuff while you’re around if there’s not decent Wi-Fi.” Another also mentioned that “you have to buy a separate iPad if you want to use it out and about everywhere, the cellular one, and 3G so that you can just use it anywhere. The ones at school are just Wi-Fi so it’s harder to use it anywhere”. The ownership of the iPad has also become a supporting facility problem, because teachers and students having iPads might resort to different methods of teaching and learning. It was clear from the concerns of T3, for example, the potential for “a member of staff who doesn’t have an iPad and really doesn’t know the potential of them”. However, as T2 stated, even teachers who have iPads, if they are not aware critically of the affordance of the iPad, may not use it well: “the biggest limiting factor to using iPads is the teachers’ knowledge of what’s available to use, how to use it and how best to get out of it to deliver what they want to deliver basically”. T2 also pointed out that iPad-based M-learning should not replace interaction between people: “as well there is no substitute for one to one contact obviously and successful teaching is built on successful relationships and you can’t have a relationship with somebody through an iPad”. He also commented that, due to the popularity of the iPad, many other brand tablets are now being influenced: “The limitations for those students, what I’m a bit wary of is the fact that I don’t want them to have like blinkers on, think it’s Apple or nothing. It can be quite worrying to think it’s Apple or no way”.

How were CE people trained and supported in order to use iPad-based mobile learning?

How were they supported?

Based on the answers given by the research participants, the school has been adopting various methods to support iPad-based M-learning. This support is demonstrated in the school policy, wifi facility, expectations of students, and the iPad group. The school has been offering a buy back policy, which was explained by T3 thus: “it’s like a hire purchase scheme so what you do if you pay a monthly fee and then at the end of your two years there is a buy back policy”; another student added: “at the end of the scheme you’ve got to pay £10 and then that’s yours then...the scheme is over 4 years and you pay in monthly instalments”. It is known that the iPad is a costly product, and according to the teacher “a larger proportion of students [are] coming on board but not every student has an iPad”; therefore to some extent this policy might eliminate a dire situation as regards availability of iPads. As a consequence, many teachers and students indeed buy their iPads using the scheme, for example, “I’ve bought into the scheme and the scheme I felt for me; I don’t know if it offered the best value, it just seemed an easier route, I didn’t have to go into a shop and sit there and get the best deal and listen to all the chat. I could just sign up and get that done.” (T3)

In this way, this policy also makes buying an iPad easier. Wifi and the school’s online interactive platform also show the supportive insurance of iPad-based mobile learning. The former is essential for the iPad to connect to the internet, and the latter allows students and staff to interact. According to one student, “they (school) have set them up with internet and the network so that you can access your files that are on the computers on your iPad as well which made it easier when you’re at home to do work”. In a recent Ofsted report, this school is rated as ICT affluent, in that wifi is accessible in every classroom. According to T2, a visual learning environment is required for students and teachers to interact. As has been discussed, a Twitter account has been set up for each module in order to encourage communication. Most importantly, teachers’ beliefs and expectations about the value of the iPad to students are also supportive. Although this idea has not been recognised by many people as yet, according to one student, teachers’ expectations really count. As they responded, “they’re encouraging us to use it in lessons”; “we were just like expected to pick it up because we’re used to technology so we can learn quite quick how to use the technology. So I think we were just kind of expected to know how to use it.” In addition to this, the iPad group is another support system offered by the school. According to T2, “there’s an iPad group which meets every fortnight I think and that talks about apps that are being used in classrooms, how good it is, what to watch out for, new things”. He further hinted that teachers also communicate with each other there, about different apps.

How were they trained?

In terms of training for iPad-based M-learning, according to their responses the interviewees were both school trained and self trained, although self training appeared to be of greater significance. T3 stated that “I was not trained to use an iPad...so for me it’s always been self-training, looking things up and speaking to other people about how to do it”. But then he added that he had some training at school:

“We have had some school training in a training day and a gentleman from Apple came in, this was a couple of years ago and he showcased what the iPad would be able to do. I: Was the affordance he showed related to education? R: Not particularly, I don’t think so. I: Quite general? R: Yeah.”

Similarly, T2 claimed that “I: You learn by yourself most of the time, the school teaches you a little bit but most

of the ideas..? R: It's probably a 60-40, 60 me, 40 school." When the students were asked how they were trained to use iPad-based M-learning. One student responded: "I think we were just like expected to pick it up because we're used to technology so we can learn quite quick how to use the technology. So I think we were just kind of expected to know how to use it."

Teacher-student irregular communication is another way of training. This kind of training is random and in many cases essential. T3 gave some examples of this, "I personally go round and ask them... what are you doing, what have you got and have you thought of this? When there's a spare minute in class I'll so say have you thought about this and then obviously therefore we have a discussion about what they're using"; "we can offer apps for students." Similarly, T2 claimed "I ask them if you've found any apps which are interesting that we might be able to use. Every so often you hear back from them." These actions have been confirmed by students:

"If there's a new app that we've got and we don't know how to work it we'll ask the teacher how and then they'll like demonstrate to us"; "especially creative engineering at the beginning of every lesson our teacher would normally say oh I found a new app on the market which specialises in what we're doing at the moment and that's a good way because you know...teachers do let us know of new apps on the market that will help progress our learning."

DISCUSSION

What do they think are the advantages of iPad-based M-learning?

A perception shared by the teachers in this study is that the combination of iPad-based M-learning and PBL pushes students to be more independent. This independence has also been recognised by Kinash (2010) and Garcia (2011), who advocated that M-learning could turn students into more proactive and autonomous learners who direct themselves in their learning. Resilience was also mentioned in the findings, which is consistent with Garcia's (2011) claim that, through M-learning, students know what resources to utilise in order to solve problems; furthermore, Kinash (2011) claimed that students could understand 'ways of responding and can choose creative formats that best demonstrate their learning' as a result. The aforementioned problem-solving skills identified in the research findings could also be related to the outcomes of diversification and enrichment in learning experiences (Peter, 2009), such as situated learning (Klopfer and Squire, 2005), which means having students learn to deal with lifelike problems in emulated situations. Most importantly, this finding (problem-solving) could satisfy ABET's (the US engineering degree accreditation organisation) requirement for future engineers: 'learning to... solve engineering problems is an essential outcome for engineering graduates' (ABET, 2010, quoted in Marra et al., 2011, p.124). Creativity was also mentioned by T1, in a manner similar to that Jahnke (2011) advocated; i.e. that students' creativity could be enhanced with technology enhanced learning.

In the findings, the forward-thinking ethos of using iPad-based M-learning was also echoed by what Adam and Felder (2008) described, in that engineering students should show their abilities in the application of new knowledge and technology. This finding is additionally consistent with the opinions of Garcia (2010), and Wakefield and Smith (2012), in that being able to use iPad-based M-learning is essential for students' futures. The findings also demonstrate that the constant levels of feedback the iPad supports was welcomed by Kinash (2011) too. The CE teacher said that the collaborative nature of iPad based M-learning was beneficial, which was mirrored by George and Serna's (2010) opinion regarding the facilitation of the iPad for students to work collaboratively. The self-management and support offered by the iPad is further reflected by Klopfer and Squire (2005). In addition to these, the apps, speed of accessibility to internet, mobility, convenience and multi-functionality are all reflected by Wray (2011).

In the findings, some Pre-CE students claimed that iPad-based M-learning was fun, which is consistent with what Hartnell-Young and Heym (2007) said regarding teenagers being more open to m-devices. However, not everyone felt that iPad-based M-learning would make their learning fun, as with the CE students. Similarly, these Pre-CE students also commented that the iPad could replace the computer suite, which to some extent is consistent with Wray's (2011) proposition that eventually students may no longer need ICT suite. However, the CE participants themselves found that the iPad could not replace the functionality of the iMac. The results show that the CE students' attitudes towards iPad-based M-learning were apparently more serious, objective and rational, which could be due to their experiences using different devices to complete their projects during their CE course. According to Melhuish and Falloon (2010), an objective awareness of the affordances of the iPad is essential in applying the device. Therefore, this finding to some extent initiates some templates for other institute leaders or curriculum developers to use as a base for how to teach students to consider m-devices critically. This finding is also a breakthrough in terms of the long-held superstitions surrounding the benefits of M-learning (Jardine, Clifford and Friesen, 2008).

To what extent do those involved with CE think the iPad-based M-learning could transform and improve students' learning and their grades? How could the result be assessed?

In general, the CE staff were positive about the possibility of iPad-based M-learning to transform and improve students' learning, albeit with an awareness of the limitations of the iPad. This result is consistent with some other authors' attitudes towards M-learning devices (Jardine, Clifford and Friesen, 2008). In terms of CE students' improved academic outcomes, T3's opinion was that the constant feedback from formative assessments supported by the iPad was working on students' learning well; this result was predicted by Kinash (2011). However, as mentioned, not every CE student agreed with the improvements made possible by the iPad. One of the reasons behind this was that they may have always been good at a certain subject and their grade for that subject was already high, so the application of iPad-based M-learning did not make a difference to their grade. This finding is consistent with that of Kinash (2011), who claimed that many external factors can influence assessment of the outcomes of iPad-based M-learning.

Unlike the negative issues raised by previous authors, such as Brand et al. (2011), in terms of the validity of M-learning, particularly, the results of M-learning regarding the improvement in students being difficult to test this research has raised some different views. Firstly, a course such as CE, which was designed not for examination, should not be expected to track students' learning and progress via a comparison of their grades on tests. Secondly, the PBL pedagogy of the CE module also dictates that formative assessment in this context could be the more suitable option for students' learning; this is because "in PBL settings, students may feel disempowered by assessment methods that do not match their PBL experiences" (Savin-Baden, 2004, cited in Marra et al., 2011, p.125), such as tests, but feedback from the teacher is what the learning of engineering students relies on in order to further their projects (Marra et al., 2011), which was confirmed by T1, T2 and T3. Therefore, it is not necessary to use a summative assessment (test) to discover whether students' potential learning improved through iPad-based M-learning in the context of CE, and the students' improved outcomes may not always be best demonstrated through tested outcomes, such as the CE case. Therefore, this result poses a criticism of the work of Brand et al. (2011), which stated that M-learning is not valid, due to the difficulty of testing it; it leads to the observation that test results cannot represent fulfilment of learning outcomes in every context. Interestingly, in an interview with another group of pre-CE students, one said affirmatively that his literacy mark rose after using the iPad, and his reason was that the iPad could correct his spelling mistakes; thus, compared to his previous work that included spelling mistakes in assignments, the current grade was improved, also highlighting the limitations of Brand et al. (2011). Therefore, both of these examples are valuable in challenging previously held opinions about the difficulty of assessing M-learning outcomes (Brand et al., 2011), and a case by case assessment of the outcomes of M-learning is necessary.

The debate as to whether the iPad is just another learning resource

From the findings, it can be seen that T2 is positive as regards the iPad's potential to transform learning. However, T1 and T3 stressed that the iPad could also be a learning resource but that it has become part of learning as a whole. As T1 stated, 'it has become a part of you and your life and it allows you to do things in your life or a lifestyle that you wouldn't have had.' This reply could be symbolic of iPad as an external resource that also participates and alters student learning. Furthermore, from the perspective of educational neuroscience, cognitive pleasure could contribute to higher learning (Sadlo, 2011). As the findings show, some students felt they were having fun, which could be regarded as triggering cognitive aspects of motivation when they used the iPad to study. According to Le Merrer (2009), cited in Sadlo (2011, p.440), "internally generated endorphins may be released to reward our innate hunger for information", when students feel they are having fun (students have termed cognitive pleasure) due to using the iPad. Furthermore, as said by Sadlo (2011, p.440), "the human brain is 'wired for pleasure' according to Biederman and Vessel (2006, p.249) and we have been using substances to stimulate these particular neural system for millennia". In this case, the iPad could be regarded as the stimulating substance. Therefore, although the iPad may be regarded as an external resource, due to this feeling of fun, learning efficiency may be improved. This answer is to some extent contradicted by what Bowen (2012, p.xiv) claimed, however, in that "new technology will not alter the way brains function and human being learn." It is also in contradiction with Brand et al.'s (2011) opinion, that M-learning devices cannot change learning.

According to Gould (2012), an informal and relaxed learning climate is very important in order for learning to occur. Similarly, again from the perspective of educational neuroscience, a relaxed learning environment is important: "cognition is enhanced when stress is low because the heart sends more blood to the cortex" (McCraty, 2002, cited in Sadlo, 2011, p.441) and "reducing stress within the learning environment needs to become the highest priority for teachers everywhere" (Sadlo, 2011, p.441). Thus, when learners feel they are having fun and are relaxed while they are studying on iPad, learning is rewarded; disputing Brand et al.'s (2011, p.170) point that, "learning takes place naturally ... regardless of adjectival contexts of learning". In general, the iPad as a learning resource is changing learning as a whole.

What do those involved with CE think are the disadvantages of iPad-based M-learning?

The disadvantages of the iPad, as seen in the findings, are as follow: some problems with default operation system of iPad, problems with apps, the supporting facilities, the ownership of the iPad, doubts in teachers' critical awareness of the iPad's affordance, the compatibility between the iPad and other brand products, and that it still cannot beat face-to-face teaching. Some of the limitations were first discovered when those involved with CE were engaged in research and projects; for example, the problems with regard to the iPad operation system and apps. Although Wray (2011) claimed that the OS (iPad operation system) has many advantages, such as the extended the battery usage time, CE teachers and students said that this system could not surpass the iMac in some forms of industry design processing. Similarly, apps on the iPad are highly thought of by many people, such as Wray (2011), but from the interviews we know that the apps' manufacturers made two versions: one for iPads and the other for computer use, the latter of which has been found to be superior by those involved with CE. Furthermore, the precision of the mouse and processing capabilities of iPad CPU, and even the storage for saving files are not well thought of by those involved in CE.

Some limitations were already been noticed before, such as whether teachers can critically evaluate the affordances of the iPad; ownership and whether each person can have one, along with access to supporting facilities. The former point was confirmed by Melhuish and Falloon (2010), as they claimed that failing to offer full access might cause poor utilisation of the iPad. The ownership of the iPad was in fact mentioned by Traxler (2010), who stressed that the efficacy of the iPad could only be optimised when each person had one. In the context of school A, if in one class some students have iPads and other do not, the teachers would have to prepare two kinds of lesson, which is problematic. Meanwhile, supporting facilities mentioned by those involved with CE concerned Wifi, which was consistent with the issues raised by Garcia (2011).

However, the current study also raises two interesting arguments: one is the compatibility between the iPad and other brand products, and the other is that it cannot surpass face-to-face teaching. The latter point is not a new one. Before the birth of the iPad, the pros and cons of face-to-face education and distance education were widely debated. An opinion from educational neuroscience may provide an explanation for this limitation; according to McCraty et al. (2005, cited in Sadlo, 2011, p.438), "electro-magnetic fields of the heart radiate several feet from each body, and when human beings meet these fields apparently merge and enhance non-verbal communication and sensitivity to each other", which is commented on by Sadlo (2011, p.438), in that it can "explain the advantages and richer feelings of meeting personally together, rather than via internet". In terms of the former limitations, there is not a great deal of studies from which to draw information. However, the differences between the various brands of tablets should be made evident to educational practitioners.

How were those involved with CE trained and supported in order to use iPad-based mobile learning?

The "buy back" policy introduced by school A could be used by other institutes too, if they are also struggling with issues regarding ownership of iPads. This policy in school A helped both teachers and students. This finding echoes Traxler's (2010) claim, that the iPad is intended to be a personal device, the effect of which would only be realised as optimum when each person has one in hand. The school had also been improving Wifi coverage, as well as online interaction platforms such as Twitter, which could be a point of reference for other schools. The teachers' beliefs and expectations were another form of support from the school's side, which is consistent with the ideas of Morris, Ramsay and Chauhan (2012), as teacher expectation has always been influential on students' learning (Rubie-Davies, 2008); a teacher's belief, according to Pajares (1992), will to a large extent inform their teaching, which in this researcher's opinion has opened another channel of support for students and iPad-based M-learning. However, the formal training offered by the school was not satisfactory enough in the opinion of the teachers and students, and they admitted that a large portion of how to learn and teach by iPad was from their own intuition and their previous experience of using smart phones and computers. Just as T2 said, 60% of his iPad knowledge is from his own experience; plus there are some students who have claimed that they learn to use iPad by themselves, supporting the view that self training is important in iPad-based M-learning (Churchill, 2005; Morris, Ramsay, and Chauhan, 2012). It has, however, been confirmed that teacher-student communication is enriched by the students' iPad knowledge. As mentioned in the rationale, teacher-student communication and training has seldom been explored in previous studies, and the result is that this study could to some extent be pioneering in raising this issue.

CONCLUSION

In terms of what CE teachers and learners think of iPad-based M-learning, the first ground breaking finding was that CE people's attitude towards iPad-based M-learning are more objective and rational than those who are not engaged in CE. The second finding was that the CE teachers were generally positive about the benefits of iPad-based M-learning in terms of improving or changing learning. This study also challenges previous claims that the outcomes of M-learning are difficult to assess and thereby advocates a case by case assessment of the outcomes

of M-learning. The claim that mobile technology cannot change learning but is instead just another component of learning resource is also disputed by this study; which claims that the iPad as learning resource can change learning as a whole. The limitations of iPad-based M-learning in this study largely relate to the specific context of CE. Some of the limitations are consistent with previous research, but others were first discovered. In terms of how people are trained and supported to use iPad-based M-learning in CE, school policies like iPad ‘buy back’ policy, the Wifi environment, on-line interactive forum, were all found to contribute to the support for iPad-based M-learning. Another supportive aspect of this is teachers’ belief in iPad-based M-learning and their expectations of students. In terms of training, the research participants had not received formal training in iPad use at the school, but teacher-student communication, and self-training played an important role in ‘in-use’ training. However, this research is not without limitations; in particular, due to the limited sample and the case study method, the statistical generalisability of the study is limited. Due to the time allocated to observing the CE class, it was difficult to attain a comprehensive picture of how the iPad is used. In addition, as the participation of both teacher and student participants was arranged by school, the Hawthorne effect may have potentially influenced responses, influencing trustworthiness. While this study has to some extent answered the research questions set; in order to understand better how iPad-based M-learning is used in the PBL, a longer observation period or ethnographic research would be desirable in the future.

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